Baseline Water Quality Inventory for the Southwest Alaska Inventory and Monitoring Network, Kenai Fjords National Park

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Abstract

A reconnaissance level water quality inventory was conducted at Kenai Fjords National Park during May through July of 2004. This project was initiated as part of the National Park Service Vital Signs Inventory and Monitoring Program in an effort to collect water quality data in an area where little work had previously been done. The objectives were to collect baseline information on the physical and chemical characteristics of the water resources, and, where possible, relate basic water quality parameters to fish occurrence. Water temperatures in Kenai Fjords waters generally met the Alaska Department of Environmental Conservation (DEC) regulatory standards for both drinking water and growth and propagation of fish, shellfish, other aquatic life and wildlife. Water temperature standard are less than or equal to 13° C for spawning and egg and fry incubation, or less than or equal to 15° C for rearing and migration (DEC 2003). Exceptions were three ponds in Northwest Fjord and surface waters in Delight Lake and River in McCarty Fjord. Dissolved oxygen was between the DEC limits for surface waters of greater than 7 mg/l but less than 17 mg/l in freshwater, and above the regulatory limit of greater than or equal to 5 mg/l for estuaries and tidal tributaries in the majority of cases (DEC 2003). Several streams in Nuka Bay had unexplainable low dissolved oxygen of 6.19 to 6.71 mg/l. Although still above the regulatory limit, Pederson Lagoon experienced dissolved oxygen levels of 5.49 mg/l at bottom. Follow up sampling at these water bodies is recommended. Most of the water bodies in Kenai Fjords met DEC standards for pH of greater than or equal to 6.5 and less than or equal to 8.5 for both fresh and marine waters (DEC 2003). An estuarine area in Aialik Bay had a pH of less than 6.5, as did five small ponds and their outlet stream in Northwest Fjord. One stream in this same fjord experienced a pH of 9.26. Delusion Creek in McCarty Fjord had a pH below the regulatory limit, and Delight Lake showed pH levels less than 6.5 below a depth of 20 m.

Introduction

The Southwest Alaska Network (SWAN) includes five park units: Alagnak Wild River (ALAG), Aniakchak National Monument and Preserve (ANIA), Katmai National Park and Preserve (KATM), Kenai Fjords National Park (KEFJ) and Lake Clark National Park and Preserve (LACL).

Little information exists on water quality in these park units. Previous water related studies in Kenai Fjords have primarily focused on three geographic locations: Exit Glacier/Exit Creek, a series of three lakes on the McCarty Peninsula, and streams in Nuka Bay near historic gold mines (Figure 1). Hydraulic studies were carried out by the U. S. Geological Survey, Water Resources Division (USGS) along the Exit Glacier Road and at the Resurrection River bridge in 1986 (Jones 1987). USGS also maintained a stream gauging site on the Resurrection River 1964-1968 (http://nwis.waterdata.usgs.gov/ak/nwis/discharge/?site_no=15237700), and this

site has been continued by the NOAA River Forecast Center (http://aprfc.arh.noaa.gov/cgi-bin/ahps.cgi?pafc&resa2). In 2001, the National Parks Service initiated water quality studies in Exit Creek and several smaller streams near Exit Glacier as part of the Visitor Experience and Resource Protection program (Wright 2001).

The Alaska Department of Fish and Game (Edmundson et al 2001) carried out limnological studies in Delight and Desire Lakes on the McCarty Peninsula in 1981 and 1997, and sporadically in 1986 – 1987. York and Milner (1999) studied macroinvertebrate and salmonid colonization of the third lake system, informally called Delusion but sometimes Delectable or Ecstasy Lake, and collected limnological, hydrological and water quality data in all three lakes and their outlet streams.

Studies in Nuka Bay began in 1993, when Cieutat et al. (undated) collected water samples from Ferrum and Babcock Creeks, and smaller unnamed streams. Griffiths et al. (1999) and National Park Service (undated) followed through with metals analysis of stream sediment and water samples.

In addition to these geographically discrete projects, the Los Alamos Laboratory carried out a more areally extensive study in and around KEFJ in 1977, although their analytes were limited to temperature, specific conductance, pH and uranium (STORET Legacy database http://www.epa.gov/storet/). Few of their sample sites overlapped with this study.

The present study was integrated with an ongoing fish inventory (Miller 2005). Water quality data compliments fish distribution information, since poor water quality may explain the absence of fish in an otherwise suitable area. Jointly conducting water quality and fisheries inventories is also cost effective. The objectives of this study were to collect baseline information on the physical and chemical characteristics of the water resources within Kenai Fjords National Park, and, where possible, relate basic water quality parameters to fish occurrence.

Study Area

Hydrography

Water resources within KEFJ consist primarily of short steep streams flowing directly into saltwater. Larger water bodies of note include the Resurrection River, which partially follows the northeast boundary of the park and flows into Resurrection Bay; Nuka River, which drains from the crest of the Kenai Mountains into Beauty Bay at Nuka Bay and; Delight, Desire and Delusion Lakes, located to the east of McCarty Fjord (Figure 1).

Geology

The bedrock of the Resurrection Peninsula and the Kenai Fjords coast is a mixture of faulted metamorphics and intruded volcanics. An arc of cretaceous upper Jurassic rocks stretches from Kenai Fjords near Gore Point around through the Chugach Mountains, as far east as Glacier Bay. These rocks are primarily “grawyacke, slate, argillite, minor conglomerates, volcanic detritus and interbedded mafic volcanic rocks” (Beikman 1980). Several granite and granodiorite intrusions are scattered along the coast; the southern ends of the McCarthy and Harris Peninsulas are good examples. This arc of metamorphic rocks with quartz veins hosts gold-bearing arsenopyrite (Richter 1970). Historically, a number of mines and prospects were located in the Nuka Bay area.

Tectonic events, in conjunction with Pleistocene and Holocene glaciation, are the major forces that have shaped the Kenai Fjords landscape. Multiple glacial advances have left steep polished bedrock walls and deep submarine valleys all along the Kenai coast, and a mantle of glacial sediments over gentler terrain. The scalloped appearance of the Aialik, Harris and McCarty Peninsulas is due to the drowned cirques of the Chugach Mountains, partially submerged by tectonic subsidence during the Holocene (Hamilton and Nelson 1989).

Methods and Materials

During May –July 2004, a water quality technician accompanied the fish inventory crew on trips to the Resurrection River, Aialik Bay, Northwestern Fjord, Two Arm Bay in outer Northwestern Fjord, McCarty Fjord, and Nuka Bay. Core water quality parameters (Freshwater Workgroup Subcommittee 2002) including temperature, pH, conductivity, specific conductance (conductivity compensated for temperature), and dissolved oxygen and turbidity were measured in surface waters with a YSI 6600 multi-parameter sonde unit at fish sampling sites, or other areas of interest (Figure 1). Probes were calibrated according to manufacturer’s instructions prior to each trip, and for dissolved oxygen, before each day’s use. Where appropriate, conductivity was converted to salinity using the algorithm provided by the manufacturer, and constants from Standard Methods, 19th Edition (APHA 1995).

Discharge measurements (Rantz 1982) were taken with a Marsh McBirney Flowmate 2000 in most streams where fish and/or water quality were sampled. Lake levels were estimated following NPS Water Resource Division procedures (Freshwater Workgroup Subcommittee 2002), and streams and lakes were categorized as clear or glacial, based on the presence of glaciers in the watershed and glacial flour in the water.

Depth profiles were taken with the YSI near the deepest portion of Delight Lake and Pedersen Lagoon at intervals of 1 meter for the first five meters, and thereafter at every five meters. Profiling was continued from maximum depth to

the surface. Coordinates in latitude/longitude decimal degrees and NAD27 datum were collected with a Garmin GPS Map 76s or Garmin GPS III+ at sampling sites and averaged for a minimum of 30 seconds. Data was not differentially corrected.

Results and Discussion

Resurrection River watershed

All water quality measurements taken in the Resurrection River watershed (Figure 1) met Alaska Department of Environmental Conservation (DEC) standards for temperature, dissolved oxygen, and pH (Table 1). Temperatures ranged from 4.5 to 8.27° C in two clear water tributaries, and 4.03 to 4.84° C for four side channels characterized as glacial. Dissolved oxygen, at 10.45 and 11.21 mg/l, was slightly lower in the clear streams than the glacial (11.69 to 12.32 mg/l). In the clear streams, pH was measured at 6.74 and 7.53 while glacial streams ran from 7.07 to 7.75. Specific conductance was also slightly lower in glacial streams (46 to 131 µS/cm) versus clear streams (68 to 158 µS/cm). Turbidity was 2.7 and 5.1 NTU in the clear streams but 0.6 to 143.6 NTU in glacial streams (Table 2).

Exit Creek (EXCR001, EXCR002, EXCR003) water quality parameters were comparable to those found in the VERP sampling (Wright 2001), although specific conductance was slightly higher. Dissolved oxygen in the clear channel (EXCR002), at 11.21 mg/l and 86.7%, was low for Alaska, likely showing groundwater influence.

Aialik Bay

All streams sampled in Aialik Bay (Figure 1) met DEC water quality limits for temperature and dissolved oxygen but one pH measurement fell below the standards. No sampled streams were characterized as glacial. The lowest measured temperature of 2.85° C at Quicksand Creek (QUKC001Q, Figure 1) is below the limit of 4° C for salmonid spawning (McCullough 1999), although pink salmon were observed in the creek. The maximum measured temperature was 10.25° C.

Dissolved oxygen ranged from 11.12 to 14.44 mg/l, and specific conductance was measured from 20 to 329 µS/cm. pH was variable with the maximum pH of 8.5 in Northeast Aialik Creek (NAIL001) right at the regulatory level; while the minimum pH of 6.23 at Quicksand Lagoon (QUKL003) was below the regulatory limit of 6.5. No fish were caught at QUKL003, although salmonids were found in an adjacent location with a higher pH. Turbidity was low in all streams, varying from 0.1 to 5.6 NTU.

Pedersen Lagoon (PDLG001P), characterized as glacial, met DEC water quality standards for estuarine waters for all parameters, although dissolved oxygen decreased with depth.

The depth profile for Pedersen Lagoon (Figure 2) indicates a colder layer with higher turbidity and dissolved oxygen at one meter. This may be an artifact of the tidal cycle, although salinity did not vary at this depth, showing a steady increase to the bottom. Between 10 and 20 m, both temperature and dissolved oxygen showed a steep decline, with temperature stabilizing at 4.1° C below 25 m.

Percent dissolved oxygen was supersaturated from the surface to 15 m. Readings of up to 145% suggest that the dissolved oxygen membrane may have been recently replaced and needed additional time to adjust to the probe (Laura St. Pierre, YSI tech rep, personal communications, 12-20-04). At the bottom (37.3 m), dissolved oxygen jumps up 2 mg/l, but than declines to a low of 2.43 mg/l at 25 m on the upward profile (Table 1). These measurements probably reflect some de-gassing of bottom sediments upon contact with the sonde unit. Hydrogen sulfide is commonly found in marine sediments, and is one of a number of compounds that can mask oxygen readings on the sensor (Laura St. Pierre, YSI tech rep, personal communications, 12-20-04). Because of the inconsistent readings, and possibly very low dissolved oxygen, this profile should be repeated when circumstances allow.

Harrison Bay and Two Arm Bay

Five streams and six lakes were sampled in Harrison Bay/Northwest Fjord in 2004, and two alpine lakes were sampled in 2003 (Figure 1). All streams met DEC regulatory limits for temperature and dissolved oxygen but the pH of 6.23 in BOCR (unofficially called Boulder Creek) was below limits, and the pH of 9.26 in DOBC (unofficially Dropoff Beach Creek) exceeded limits. Both streams supported salmonids. These two streams, along with two others were considered clear, and all lakes were classified as clear.

Temperatures in clear streams varied from 3.53° to 8.93° C while the one glacial stream had a temperature of 4.27° C. The lowest temperature in clear streams was below the minimum temperature for salmonid spawning (McCullough 1999) and no fish were caught. Dissolved oxygen ranged from 11.99 to 14.94 mg/l for all streams, while turbidity was 9.1 NTU for the glacial stream and less than 1 NTU for all others. Specific conductance was generally low (4-22 µS/cm) for most streams. DOBC001, with a specific conductance of 384 µS/cm at the surface and 2850 µS/cm at just .2 m, was obviously saltwater influenced. Comments on the data sheet suggest that it was flooded at every tide at the sample location.

One stream, CBCR, was sampled in August, 2003 and again in June, 2004, although in slightly different locations on the creek. In 2003, the river was at flood stage, following four days of heavy rains. Between the two sampling periods,

turbidity dropped from 1471 to 0.9 NTU and temperature decreased from 8.82 to 3.53° C, but dissolved oxygen remained close to 100%. The lack of change in specific conductance (8 versus 11 µS/cm) suggests that this stream is predominately surface fed.

No profiles were taken at six lower elevation lakes or ponds that were small (< 2 ha) and shallow. Logistics prevented profiling the small but deep alpine lakes which drain into CBCR. Pond BLKC had surface temperatures above 13° C, which exceeded limits for spawning and incubation. This pond did support coho salmon, but it's unlikely that temperatures this warm would occur while eggs or alevins were present. Locations in two ponds near sea level (CBPD001, NWFP001) showed surface temperature measurements above 15° C, which exceeded regulatory standards for rearing and migration, and only threespine stickleback (*Gasterosteus aculeatus*) were caught at the water quality sampling locations. (Sockeye salmon, *Oncorhynchus nerka*, were caught at CBPD002, where surface temperature measured 14.73° C)

Five of the lower elevation lakes (BLKA, BLKB, BLKC, CBPD, NWFP) had pH measurements less than the standard of 6.5. Despite this, four of the five ponds supported either Dolly Varden (*Salvelinus malma*) or coho salmon (*Oncorhynchus kisutch*), although not necessarily at the water quality sampling point. CBPD002 showed marine influence, with a specific conductance of 2356 µS/cm, but conductance for all others, including CBPD001, ranged from 40 to 4. Turbidity was less than 2.5 NTU for all but the two sample points having high surface temperatures. CBPD001 and NWFP001 had temperatures and turbidities of 15.63° C and 46.8 NTU versus 20.44° C and 15.6 NTU.

One clear (PARA), and one glacial (PARB) stream were sampled in Two Arm Bay Temperatures were low, at 4.03 to 4.69° C, but within DEC limits. Dissolved oxygen was uniformly good, with all four measurements between 13.24 and 13.73 mg/l. pH (6.05 and 5.99) fell below regulatory limits at both streams, and fish were not caught in either stream. Specific conductance and turbidity were low for both streams, with specific conductance ranging from 18 to 23 µS/cm for all streams, and turbidity 5.1 to 6.1 NTU for the clear stream but 23.5 to 24.9 for the glacial. Low glacial turbidities are likely due to the mid-June sampling date.

McCarty Fjord

Of the four clear water and three glacial streams in McCarty Fjord (Figure 1), no temperature or dissolved oxygen readings exceeded DEC standards, although James Lagoon Creek (JLGC) exhibited temperature below the minimum for salmonid spawning (McCullough 1999). All four pH measurements in DELC tightly grouped at 6.06 to 6.13, below the DEC minimum limit of 6.5, and no fish were caught in this stream. A second clear stream, DELR, with a pH range of 6.48 to 6.68, had one of ten readings slip below the limit. All glacial streams fell within the regulatory range for pH, although DLUC recorded one of two

measurements at 6.5. A second measurement, in a slightly different location, was recorded as 6.67.

Specific conductance was comparatively high (420 to 468 µS/cm) at two clear streams, DELR and DELE, a result of sampling in an area occasionally flooded by tides. Specific conductance at other clear streams was 12-18 µS/cm, and 14 - 98 µS/cm in glacial streams. Turbidities in non-glacial streams were low, with all but one less than 10 NTU and many approaching zero. One of three turbidity readings at DELR was higher than expected at 55 NTU. Glacial turbidities ranged from 23.3 to 157.7 NTU over all streams in McCarty Fjord, but showed almost as much variability with nine measurements at JLRA (23.3 to 114.6 NTU).

Pelagic surface temperatures at Delight Lake (DELL) were quite warm, at 15.28 to 15.68° C, and above DEC limits, but in line with the maximum of 16° C reported by Edmundson et al. (2001). Higher surface temperatures of up to 19.35° C were found in shallower water along the shore but dissolved oxygen remained above 9.5 mg/l, well above regulatory limits. In two lake profiles, pH below 20 m was consistently less than state standards.

Both lake profiles show weak thermal stratification (Figures 3 and 4), in agreement with the findings of Edmundson et al (2001). On the first lake profile, dissolved oxygen varied more than 5 mg/l between downward and upward measurements at depths above 20 m and so was discounted. Three days later, in a slightly different section of the lake, dissolved oxygen showed an inverse relation to temperature with depth (Figure 4), as would be expected in this oligotrophic lake.

Specific conductance showed an insignificant increase with depth (25 to 48 µS/cm) on the first profile, very close to the 12-55 µS/cm range reported by Edmundson et al (2001). On the second profile, the probe measured very high conductivities from depth, and appears to have been tainted by bottom sediments.

Nuka Bay

Temperature, dissolved oxygen, and pH for the five clear and two glacial streams (Figure 1) all met DEC water quality standards. Temperatures in three clear streams (FERM, NUKC, NUKE) and one temperature in the glacial NUKR stream were less than the 4° C needed for salmon spawning, although four species of rearing salmonids were caught in FERM, and six in NUKR. No fish were caught in NUKC, and NUKE was not sampled for fish. The clear NUKD showed lower than expected dissolved oxygen of 9.09 mg/l or 75%. Dissolved oxygen was even lower for an estuarine pond, NUKP, at 6.64 mg/l. The glacial NUKR showed dissolved oxygen levels of 13.54 mg/l or 101.6% in a riffle, but just upstream in a glide, a series of three measurements averaged 6.32 mg/l or 51.3%. Although still within State water quality standards, these low levels in a rapidly flowing

stream with a cool temperature of 6.29° C, are unexplainable and make NUKR a good candidate for future study.

Conclusions

This survey provided some basic information on surface water chemistry in Kenai Fjords National Park. Because sampling was of short duration and some sample sites were tidally influenced, results should be interpreted cautiously.

Water quality regulations usually target sensitive species such as salmonids, yet in this investigation salmonids were frequently found when water quality did not meet DEC limits. Several factors may explain this. These water quality readings were essentially instantaneous, point measurements, and may not reflect conditions over time or space. As the lake profiles demonstrate, surface water temperatures may be too high, but they rapidly decline with depth. Streams offer other temperature refugia, such as over hanging banks, groundwater seepages, or discharge areas from the hyporheic zone. Water quality standards are also set above lethal conditions, so salmonids may trade off short term stressful conditions for other needs, such as food or to avoid competition.

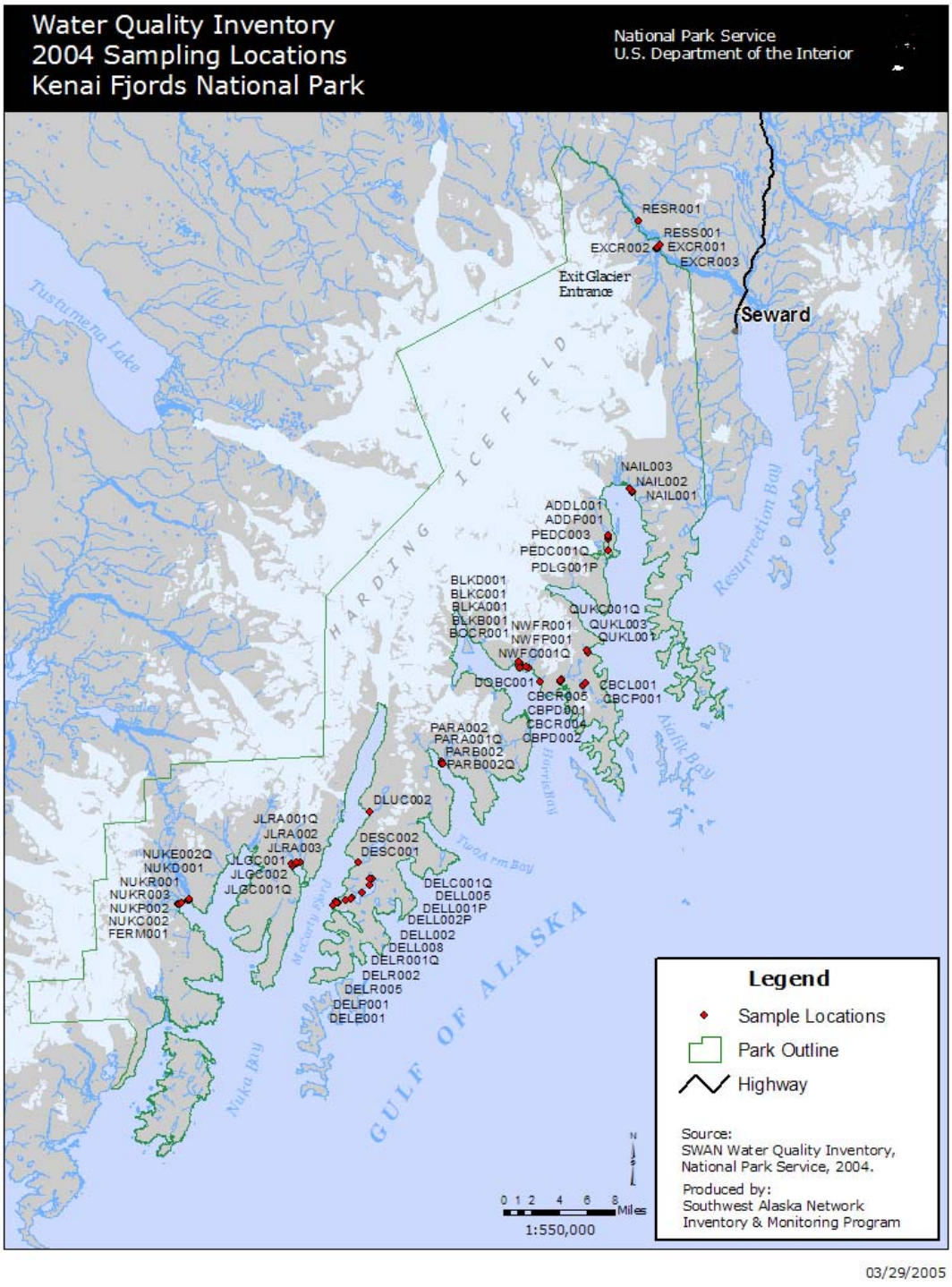

Figure 1. Water quality sample locations in Kenai Fjords National Park, May-July 2004, August 2003

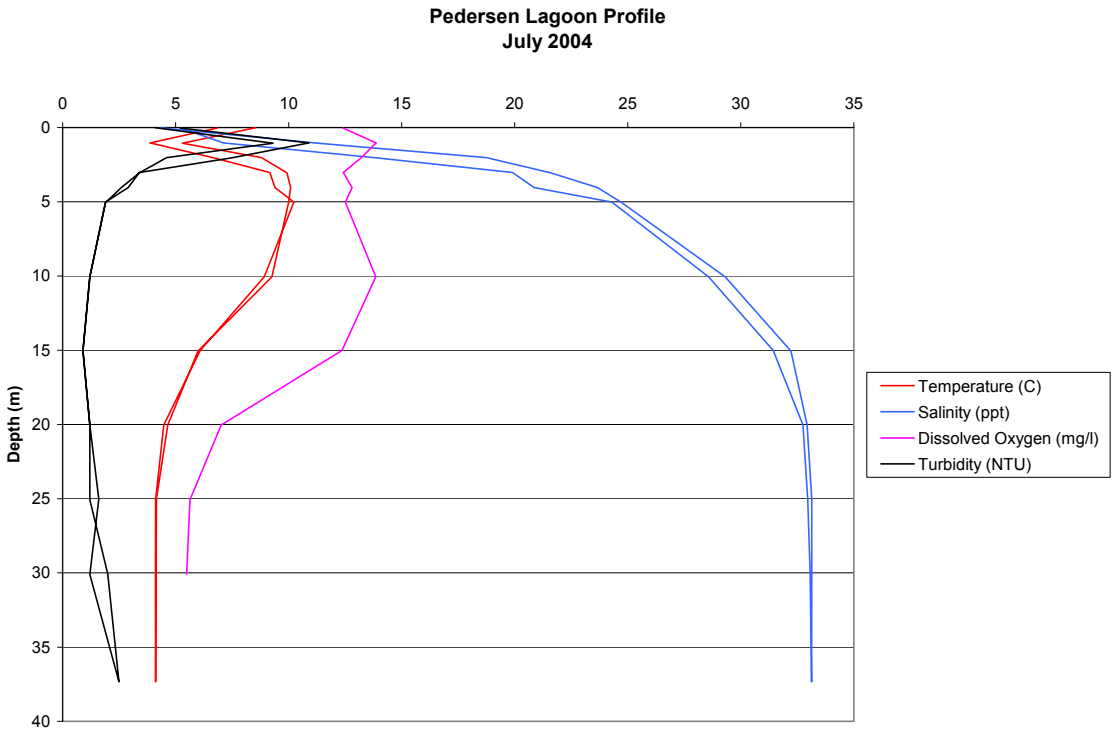

Figure 2. Pederson Lagoon Profile, Kenai Fjords National Park, July 19, 2004. Temperature, turbidity and dissolved oxygen show a discontinuity at 1 m, and temperature stratification below 5 m. Despite a decrease in temperature, dissolved oxygen also decreases with depth, indicating persistent stratification with lack of circulation.

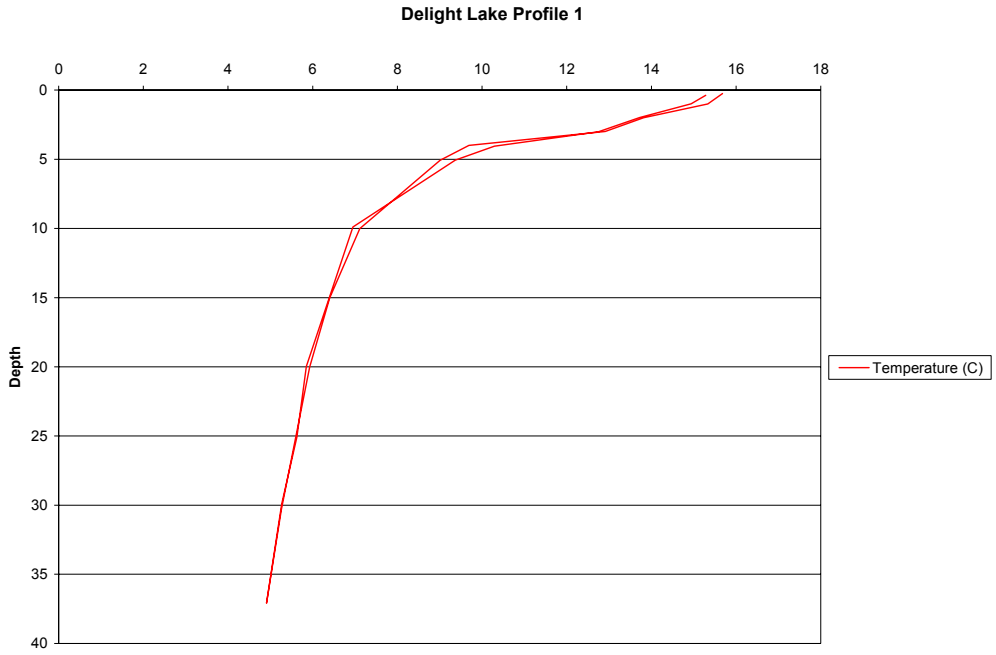

Figure 3. Delight Lake Profile 1, Kenai Fiords National Park, June 24, 2004. Weak temperature stratification.

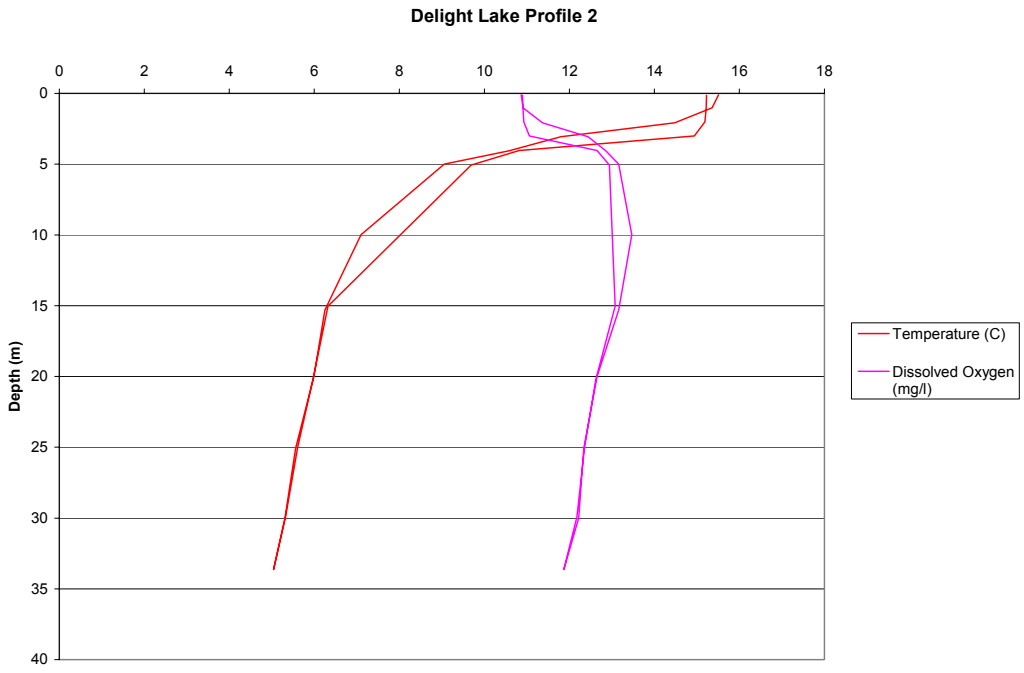

Figure 4. Delight Lake Profile 2, Kenai Fjords National Park, June 27, 2004. Dissolved oxygen increases with depth, as temperature decreases.

Table 1. State of Alaska Water Quality Standards (Excerpted from 18 ACC 70.020, DEC 2003)

Water Quality Standards for Fresh Water Uses	
POLLUTANT & WATER USE	**CRITERIA**
(3) Dissolved Gas, for Fresh Water Uses	
(A) Water Supply (i) drinking, culinary, and food processing	Dissolved oxygen (D.O.) must be greater than or equal to 4 mg/l (this does not apply to lakes or reservoirs in which supplies are take from below the thermocline or to groundwater)
(C) Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife	D.O. must be greater than 7 mg/l in waters used by anadromous or resident fish……For waters not used by anadromous or resident fish, D.O. must be greater than or equal to 5 mg/l. In no case may D.O. be greater than 17 mg/l. The concentration of total dissolved gases may not exceed 110% of saturation at any point of sample collection
(6) pH for Fresh Water Uses	
(A) Water Supply (i) drinking, culinary, and food processing	May not be less than 6.0 or greater than 8.5.
(C) Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife	May not be less than 6.0 or greater than 8.5. May not vary more than 0.5 pH units from natural conditions.
(10) Temperature for Fresh Water Uses	
(A) Water Supply (i) drinking, culinary, and food processing	May not exceed 15°C.
(C) Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife	May not exceed 20°C at any time. The following maximum temperatures may not be exceeded, where applicable: Migration routes 15°C Spawning areas 13°C Rearing areas 15°C Egg and fry incubation 13°C
(12) Turbidity, for Fresh Water Uses	*Not applicable, defined in terms of increase above natural conditions*
Water Quality Standards for Marine Uses	
(15) Dissolved Gas, for Marine Waters	
(C) Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and	Surface dissolved oxygen (D.O.) concentration in coastal waters may not be less than 6 mg/l

Wildlife	for a depth of one meter except when natural conditions cause this value to be depressed. D.O. may not be reduced below 4 mg/l at any point beneath the surface. D.O. concentrations in estuaries and tidal tributaries may not be less than 5.0 mg/l except where natural conditions cause this value to be depressed. In no case may D.O. levels exceed 17 mg/l. The concentration of total dissolved gases may not exceed 110% saturation at any point of sample collection.
(18) pH for Marine Water Uses	
(C) Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife	May not be less than 6.5 or greater than 8.5, and may not vary more than 0.2 pH units outside of the naturally occurring range.
(22) Temperature, for Marine Water Uses	*Not applicable, defined in terms of change from natural conditions*
(24) Turbidity, for Marine Water Uses	*Not applicable, defined in terms of change from natural conditions*

Table 2. Kenai Fjords National Park
2004 Water Quality Inventory

Resurrection River

CLEAR LOTIC

Site/Obs	Depth m	Temp C	Spec Cond. uS/cm	DO %	DO Conc. mg/L	pH	Turbidity NTU
RESS001 WQ01	0.04	8.27	68.00	88.90	10.45	6.74	2.70
EXCR002 WQ01	0.05	4.50	158.00	86.70	11.21	7.53	5.10
Summary for CLEAR LOTIC (2 detail records)							
Min	0.04	4.50	68.00	86.70	10.45	6.74	2.70
Max	0.05	8.27	158.00	88.90	11.21	7.53	5.10

GLACIAL LOTIC

Site/Obs	Depth m	Temp C	Spec Cond. uS/cm	DO %	DO Conc. mg/L	pH	Turbidity NTU
EXCR003 WQ01	0.14	4.82	126.00	95.70	12.28	7.69	107.40
EXCR001 WQ01	0.05	4.84	131.00	96.10	12.32	7.75	143.60
RESR001 WQ01		4.03	46.00		11.69	7.07	0.60
RESR001 WQ01		4.43	71.00		12.57	7.29	14.00
Summary for GLACIAL LOTIC (4 detail records)							
Min	0.05	4.03	46.00	95.70	11.69	7.07	0.60
Max	0.14	4.84	131.00	96.10	12.57	7.75	143.60
Summary for Resurrection River (6 detail records)							
Min	0.04	4.03	46.00	86.70	10.45	6.74	0.60
Max	0.14	8.27	158.00	96.10	12.57	7.75	143.60

Aialik Bay

CLEAR LOTIC

Site/Obs	Depth m	Temp C	Spec Cond. uS/cm	DO %	DO Conc. mg/L	pH	Turbidity NTU
PEDC003 WQ01	0.16	7.43	93.00	104.60	12.56	7.19	0.70
QUKL003 WQ01	0.13	9.50	123.00	97.40	11.12	6.23	1.00
QUKC001Q WQ01	0.21	2.85	20.00	100.30	13.55	6.80	0.70
PEDC001Q WQ01	0.18	7.85	86.00	103.80	12.34	7.29	0.40
NAIL001 WQ01	0.06	10.25	329.00	127.30	14.28	8.50	2.70
NAIL002 WQ01	0.10	4.54	71.00	102.80	13.28	6.91	0.10
NAIL002 WQ02	0.28	5.15	82.00	103.50	13.16	7.18	0.10
QUKL001 WQ01	0.54	4.78	83.00	99.90	12.82	7.04	0.20
NAIL003 WQ01	0.11	5.15	59.00	113.50	14.44	7.24	4.80
NAIL003 WQ01	0.34	5.32	60.00	104.60	13.24	7.24	5.60
Summary for CLEAR LOTIC (10 detail records)							
Min	0.06	2.85	20.00	97.40	11.12	6.23	0.10
Max	0.54	10.25	329.00	127.30	14.44	8.50	5.60

CLEAR LENTIC

Site/Obs	Depth m	Temp C	Spec Cond. uS/cm	DO %	DO Conc. mg/L	pH	Turbidity NTU
ADDL001 WQ01	0.46	6.63	62.00	100.10	12.26	7.25	1.30
ADDL001 WQ01	0.46	6.60	63.00	100.60	12.33	7.39	4.30
ADDP001 WQ01	0.06	12.31	48.00	91.50	9.79	6.55	20.50
ADDL001 WQ01	0.47	6.59	66.00	100.40	12.31	7.32	7.60
Summary for CLEAR LENTIC (4 detail records)							
Min	0.06	6.59	48.00	91.50	9.79	6.55	1.30
Max	0.47	12.31	66.00	100.60	12.33	7.39	20.50

GLACIAL LENTIC

Site/Obs	Depth m	Temp C	Spec Cond. uS/cm	DO %	DO Conc. mg/L	pH	Turbidity NTU
PDLG001P WQ01	15.05	5.99	50,079.00	38.60	3.88	7.94	0.90
PDLG001P WQ01	10.06	9.26	45,571.00	56.90	5.42	8.19	1.20
PDLG001P WQ01	4.04	9.39	33,458.00	127.90	12.81	8.24	2.90
PDLG001P WQ01	10.05	8.92	44,574.00	143.80	13.85	8.15	1.20
PDLG001P WQ01	1.06	5.30	19,222.00	50.80	5.96	8.37	9.30
PDLG001P WQ01	2.02	8.80	30,373.00	56.20	5.78	8.30	4.60
PDLG001P WQ01	3.05	9.92	34,486.00	56.00	5.52	8.27	3.40
PDLG001P WQ01	2.04	6.67	23,122.00	118.30	13.21	8.32	7.50

PDLG001P	WQ01	3.02	9.17	32,070.00	122.60	12.42	8.25	3.40
PDLG001P	WQ01	0.03	6.84	9,354.00	105.40	12.41	7.91	5.20
PDLG001P	WQ01	5.05	9.99	39,014.00	56.90	5.48	8.25	1.90
PDLG001P	WQ01	1.04	3.88	12,565.00	110.70	13.87	8.20	10.90
PDLG001P	WQ01	4.04	10.09	37,469.00	55.70	5.40	8.26	2.60
PDLG001P	WQ01	20.03	4.66	51,325.00	24.90	2.58	7.69	1.20
PDLG001P	WQ01	5.02	10.23	38,388.00	130.10	12.51	8.22	1.90
PDLG001P	WQ01	0.02	8.53	7,737.00	52.70	6.00	7.93	4.10
PDLG001P	WQ01	15.01	6.09	48,941.00	122.60	12.36	7.93	0.90
PDLG001P	WQ01	20.03	4.48	51,101.00	67.50	7.02	7.65	1.20
PDLG001P	WQ01	25.07	4.12	51,472.00	53.90	5.64	7.52	1.20
PDLG001P	WQ01	30.08	4.11	51,618.00	52.50	5.49	7.51	2.00
PDLG001P	WQ01	37.33	4.12	51,712.00	71.60	7.48	7.45	2.50
PDLG001P	WQ01	30.11	4.13	51,729.00	43.90	4.59	7.51	1.20
PDLG001P	WQ01	25.04	4.15	51,729.00	23.30	2.43	7.51	1.60
Summary for GLACIAL LENTIC (23 detail records)								
Min		0.02	3.88	7,737.00	23.30	2.43	7.45	0.90
Max		37.33	10.23	51,729.00	143.80	13.87	8.37	10.90
Summary for Aialik Bay (37 detail records)								
Min		0.02	2.85	20.00	23.30	2.43	6.23	0.10
Max		37.33	12.31	51,729.00	143.80	14.44	8.50	20.50

Northwestern Fjord

CLEAR LOTIC

Site/Obs	Depth m	Temp C	Spec Cond. uS/cm	DO %	DO Conc. mg/L	pH	Turbidity NTU
CBCR005 WQ01	1.12	8.82	8.00	100.40	11.65	6.07	1,471.10
BOCR001 WQ01	0.48	8.93	4.00	103.60	11.99	6.23	0.00
CBCR004 WQ01	0.48	3.53	11.00	102.70	13.64	6.68	0.90
DOBC001 WQ01	0.11	5.81	394.00	110.60	13.81	8.33	0.00
DOBC001 WQ01	0.26	7.01	2,850.00	124.30	14.94	9.26	0.00
NWFC001Q WQ01		5.71	22.00	100.60	12.64	6.72	0.00
Summary for CLEAR LOTIC (6 detail records)							
Min	0.11	3.53	4.00	100.40	11.65	6.07	0.00
Max	1.12	8.93	2,850.00	124.30	14.94	9.26	1,471.10

GLACIAL LOTIC

Site/Obs	Depth m	Temp C	Spec Cond. uS/cm	DO %	DO Conc. mg/L	pH	Turbidity NTU
NWFR001 WQ01	0.16	4.27	20.00	102.80	13.38	6.91	9.70
Summary for GLACIAL LOTIC (1 detail record)							
Min	0.16	4.27	20.00	102.80	13.38	6.91	9.70
Max	0.16	4.27	20.00	102.80	13.38	6.91	9.70

CLEAR LENTIC

Site/Obs	Depth m	Temp C	Spec Cond. uS/cm	DO %	DO Conc. mg/L	pH	Turbidity NTU
BLKB001 WQ01	0.13	8.77	4.00	105.80	12.30	6.30	2.50
NWFP001 WQ01	0.22	20.44	32.00	110.60	9.96	6.44	15.60
CBCL001 WQ01	-0.37	10.39	7.00	97.10	10.86		0.00
CBCL001 WQ01	-0.29	10.40	7.00	96.80	10.83		0.00
BLKD001 WQ01	0.34	6.99	5.00	102.50	12.44	6.86	1.50
CBCL001 WQ01	-0.15	10.40	7.00	106.10	11.86		0.00
CBPD002 WQ01	0.12	15.63	2,356.00	103.50	10.22	6.48	46.80
BLKA001 WQ01	0.40	8.34	4.00	104.60	12.28	6.28	0.00
BLKA001 WQ01	0.16	8.82	4.00	104.50	12.13	6.21	0.00
CBPD001 WQ01	0.26	14.73	40.00	113.20	11.48	6.68	0.90
BLKC001 WQ01	0.38	13.33	5.00	107.00	11.19	6.45	0.00
CBCP001 WQ01	-0.60	10.23	6.00	97.50	10.94	6.54	
Summary for CLEAR LENTIC (12 detail records)							
Min	-0.60	6.99	4.00	96.80	9.96	6.21	0.00
Max	0.40	20.44	2,356.00	113.20	12.44	6.86	46.80

Summary for Northwestern Fjord (19 detail records)							
Min	-0.60	3.53	4.00	96.80	9.96	6.07	0.00
Max	1.12	20.44	2,850.00	124.30	14.94	9.26	1,471.10

Two Arm Bay

CLEAR LOTIC

Site/Obs	Depth m	Temp C	Spec Cond. uS/cm	DO %	DO Conc. mg/L	pH	Turbidity NTU
PARA001Q WQ01	0.05	4.69	18.00	102.90	13.25	6.04	5.60
PARA001Q WQ01	0.05	4.68	18.00	103.30	13.31	6.06	5.10
PARA001Q WQ01	0.05	4.70	18.00	102.90	13.24	6.06	6.10
Summary for CLEAR LOTIC (3 detail records)							
Min	0.05	4.68	18.00	102.90	13.24	6.04	5.10
Max	0.05	4.70	18.00	103.30	13.31	6.06	6.10

GLACIAL LOTIC

Site/Obs	Depth m	Temp C	Spec Cond. uS/cm	DO %	DO Conc. mg/L	pH	Turbidity NTU
PARB002Q WQ01	0.15	4.03	23.00	104.70	13.72	5.99	24.90
PARB002Q WQ01	0.15	4.03	23.00	104.80	13.73	5.99	23.50
Summary for GLACIAL LOTIC (2 detail records)							
Min	0.15	4.03	23.00	104.70	13.72	5.99	23.50
Max	0.15	4.03	23.00	104.80	13.73	5.99	24.90
Summary for Two Arm Bay (5 detail records)							
Min	0.05	4.03	18.00	102.90	13.24	5.99	5.10
Max	0.15	4.70	23.00	104.80	13.73	6.06	24.90

McCarty Fjord

CLEAR LOTIC

Site/Obs	Depth m	Temp C	Spec Cond. uS/cm	DO %	DO Conc. mg/L	pH	Turbidity NTU
DELC001Q WQ01	0.11	5.46	12.00	102.70	12.96	6.13	0.10
DELR002 WQ01	0.26	14.62	424.00	105.60	10.72	6.65	0.00
DELR002 WQ01	0.19	14.63	420.00	105.40	10.70	6.68	0.00
DELR005 WQ01	0.21	17.04	428.00	105.00	10.13	6.52	4.80
DELR005 WQ01	0.24	17.09	426.00	105.30	10.14	6.51	7.60
DELR001Q WQ01	0.17	14.57	427.00	107.10	10.89	6.61	0.00
DELE001 WQ01	1.17	15.01	468.00	105.70	10.64	6.76	1.40
DELE001 WQ01	0.53	15.02	443.00	105.80	10.65	6.76	0.00
DELC001Q WQ01	0.06	5.42	12.00	103.00	13.02	6.06	0.10
DELR005 WQ01	0.30	17.30	423.00	99.00	9.50	6.48	55.50
DELC001Q WQ01	0.47	5.44	12.00	103.10	13.02	6.11	0.00
DESC002 WQ01		7.72	18.00		12.48	6.88	2.10
DESC001 WQ01	0.03	8.17	37.00	90.40	10.67	7.19	0.40
DESC001 WQ01	0.03	8.17	37.00	90.40	10.67	7.18	0.30
DELR002 WQ01	0.16	14.68	423.00	105.10	10.66	6.66	0.00
DELR001Q WQ01	0.14	14.55	427.00	107.20	10.90	6.62	0.00
DELR001Q WQ01	0.19	14.55	427.00	107.20	10.90	6.63	0.00
DELR001Q WQ01	0.17	14.57	422.00	106.40	10.81	6.63	0.00
DELC001Q WQ01	0.41	5.42	12.00	103.10	13.03	6.07	0.10
Summary for CLEAR LOTIC (19 detail records)							
Min	0.03	5.42	12.00	90.40	9.50	6.06	0.00
Max	1.17	17.30	468.00	107.20	13.03	7.19	55.50

GLACIAL LOTIC

Site/Obs	Depth m	Temp C	Spec Cond. uS/cm	DO %	DO Conc. mg/L	pH	Turbidity NTU
JLGC002 WQ01	0.01	5.31	77.00	103.10	13.05	7.14	85.30
JLRA001Q WQ01	0.01	5.72	75.00	106.20	13.31	6.98	71.60
DLUC002 WQ01		4.28	14.00		13.55	6.50	27.70
DLUC002 WQ01		4.28	14.00		13.61	6.67	27.60
JLGC001Q WQ01	0.14	3.64	68.00	108.80	14.40	7.38	155.50
JLGC001Q WQ01	0.16	3.66	69.00	108.60	14.37	7.38	156.40
JLRA001Q WQ01	0.01	5.74	81.00	105.30	13.19	6.95	61.10

JLRA003	WQ01	0.10	4.73	49.00	113.00	14.53	7.23	113.70
JLRA001Q	WQ01	0.03	5.69	67.00	107.30	13.46	7.01	84.80
JLRA002	WQ01	0.01	5.42	98.00	104.30	13.18	6.88	23.30
JLGC001	WQ01	0.09	3.17	66.00	105.70	14.17	7.33	155.70
JLGC001	WQ01	0.10	3.18	66.00	105.60	14.14	7.33	157.70
JLGC002	WQ01	0.01	5.31	77.00	103.20	13.08	7.14	86.80
JLGC002	WQ01	0.01	5.31	77.00	103.40	13.10	7.14	86.50
JLRA003	WQ01	0.10	4.73	49.00	113.60	14.61	7.23	114.50
JLRA003	WQ01	0.09	4.73	49.00	113.40	14.58	7.23	114.60
JLRA002	WQ01	0.01	5.42	98.00	104.50	13.20	6.88	25.10
JLRA001Q	WQ01	0.01	5.68	58.00	107.50	13.50	7.06	91.10
Summary for GLACIAL LOTIC (18 detail records)								
Min		0.01	3.17	14.00	103.10	13.05	6.50	23.30
Max		0.16	5.74	98.00	113.60	14.61	7.38	157.70

CLEAR LENTIC

Site/Obs		Depth m	Temp C	Spec Cond. uS/cm	DO %	DO Conc. mg/L	pH	Turbidity NTU
DELL001P	WQ01	3.02	12.75	25.00	94.30	10.00	6.71	0.00
DELL002	WQ01	0.29	17.68	19.00	111.30	10.60	6.70	0.00
DELL002P	WQ01	20.22	5.97	1,093.00	101.70	12.62	6.36	0.20
DELP001	WQ01	0.44	18.75	420.00	98.60	9.18	7.28	3.40
DELP001	WQ01	0.45	18.75	417.00	98.40	9.16	7.17	3.30
DELP001	WQ01	0.45	18.75	415.00	98.10	9.14	7.16	3.20
DELL008	WQ01	0.15	14.54	24.00	112.60	11.47	6.64	0.20
DELL008	WQ01	0.17	15.16	24.00	110.10	11.06	6.68	0.30
DELL001P	WQ01	5.07	9.01	40.00	57.80	6.68	7.06	0.00
DELL008	WQ01	0.13	14.53	24.00	112.80	11.50	6.72	0.00
DELL001P	WQ01	0.99	14.94	25.00	108.30	10.93	6.68	0.00
DELL005	WQ01	0.56	18.18	25.00	70.00	6.61	6.57	0.00
DELL005	WQ01	0.55	18.08	25.00	71.30	6.74	6.61	0.00
DELL002P	WQ01	0.13	15.23	941.00	109.00	10.90	6.66	0.00
DELL002	WQ01	0.29	16.95	19.00	107.80	10.43	6.69	0.00
DELL002P	WQ01	25.07	5.56	31.00	98.00	12.34	6.27	0.30
DELL002	WQ01	0.39	18.88	25.00	102.50	9.53	6.67	0.50
DELL002	WQ01	0.40	18.83	25.00	102.50	9.54	6.67	1.00
DELL002P	WQ01	4.06	10.58	25.00	115.50	12.86	6.94	0.00

DELL002P	WQ01	15.03	6.32	1,073.00	106.30	13.08	6.61	0.20
DELL002P	WQ01	5.07	9.69	999.00	114.20	12.94	7.11	0.10
DELL002P	WQ01	3.06	11.80	25.00	114.90	12.44	6.82	0.00
DELL002P	WQ01	30.01	5.31	122.00	96.50	12.22	6.14	0.10
DELL002P	WQ01	5.00	9.06	25.00	114.00	13.16	7.08	0.00
DELL002P	WQ01	15.30	6.25	27.00	106.40	13.16	6.80	0.20
DELL002P	WQ01	33.64	5.04	1,099.00	93.30	11.87	6.09	0.20
DELL002P	WQ01	29.92	5.32	1,130.00	96.50	12.18	6.18	0.10
DELL002P	WQ01	24.98	5.61	1,108.00	98.60	12.36	6.22	0.10
DELL002	WQ01	0.29	19.35	17.00	108.30	9.98	6.68	0.00
DELL001P	WQ01	5.05	9.37	25.00	84.20	9.65	6.89	0.00
DELL001P	WQ01	20.01	5.93	42.00	68.40	8.53	6.39	0.10
DELL001P	WQ01	37.08	4.91	48.00	58.10	7.43	6.06	0.10
DELL001P	WQ01	2.99	12.91	38.00	60.00	6.33	6.77	0.00
DELL001P	WQ01	1.99	13.72	24.00	99.70	10.34	6.68	0.00
DELL001P	WQ01	4.05	10.29	22.00	85.20	9.56	6.71	0.00
DELL001P	WQ01	0.37	15.28	25.00	111.80	11.21	6.67	0.00
DELL001P	WQ01	9.90	6.95	26.00	72.20	8.77	7.05	0.00
DELL001P	WQ01	30.31	5.26	44.00	65.00	8.24	6.17	0.10
DELL001P	WQ01	19.96	5.85	28.00	69.10	8.63	6.58	0.10
DELL001P	WQ01	25.06	5.63	29.00	64.80	8.14	6.47	0.00
DELL001P	WQ01	0.24	15.68	39.00	66.90	6.64	6.63	0.00
DELL002P	WQ01	2.07	14.48	24.00	111.50	11.37	6.67	0.00
DELL001P	WQ01	2.00	13.82	38.00	59.80	6.19	6.72	0.00
DELL001P	WQ01	4.00	9.69	37.00	53.80	6.12	6.92	0.00
DELL001P	WQ01	10.01	7.11	39.00	60.80	7.36	6.99	0.10
DELL001P	WQ01	15.02	6.40	40.00	64.90	7.99	6.68	0.20
DELL001P	WQ01	29.91	5.27	32.00	61.20	7.77	6.29	0.10
DELL002P	WQ01	1.03	15.22	934.00	109.00	10.91	6.68	0.00
DELL002P	WQ01	4.03	10.82	985.00	114.60	12.65	6.99	0.00
DELL002P	WQ01	1.02	15.36	24.00	109.10	10.91	6.64	0.00
DELL002P	WQ01	20.00	5.99	28.00	101.60	12.65	6.49	0.10
DELL002P	WQ01	2.01	15.19	925.00	109.10	10.93	6.70	0.00
DELL002P	WQ01	3.00	14.94	915.00	109.80	11.06	6.74	0.00
DELL002P	WQ01	0.10	15.51	24.00	109.00	10.87	6.62	0.00

DELL002P	WQ01	9.99	7.10	26.00	111.20	13.47	7.19	0.10
DELL001P	WQ01	1.01	15.33	39.00	63.00	6.30	6.67	0.00
Summary for CLEAR LENTIC (56 detail records)								
Min		0.10	4.91	17.00	53.80	6.12	6.06	0.00
Max		37.08	19.35	1,130.00	115.50	13.47	7.28	3.40
Summary for McCarty Fjord (93 detail records)								
Min		0.01	3.17	12.00	53.80	6.12	6.06	0.00
Max		37.08	19.35	1,130.00	115.50	14.61	7.38	157.70

Nuka Bay

CLEAR LOTIC

Site/Obs	Depth m	Temp C	Spec Cond. uS/cm	DO %	DO Conc. mg/L	pH	Turbidity NTU
NUKD001 WQ01	-0.01	6.94	418.00	75.80	9.21	7.56	1.20
NUKP002 WQ01	-0.01	10.83	2,378.00	60.40	6.64	6.78	64.30
NUKE002Q WQ01	0.31	3.65	57.00	93.30	12.34	7.23	0.00
NUKE002Q WQ01	0.31	3.62	57.00	93.30	12.35	7.24	0.00
NUKP002 WQ01	-0.01	10.82	2,378.00	61.00	6.71	6.78	66.00
FERM001 WQ01	-0.04	2.77	30.00	103.20	13.98	7.15	7.10
NUKC002 WQ01	0.31	3.58	62.00	95.40	12.64	6.94	2.50
NUKC002 WQ01	0.31	3.58	61.00	95.30	12.63	6.95	2.50
FERM001 WQ01	0.18	2.79	30.00	106.10	14.37	7.13	7.00
FERM001 WQ01	0.09	2.79	30.00	106.60	14.43	7.13	7.10
FERM001 WQ01	0.11	2.79	30.00	107.60	14.56	7.15	6.90
FERM001 WQ01	0.00	2.77	30.00	103.20	13.97	7.14	7.10
NUKD001 WQ01	-0.01	6.92	417.00	74.80	9.09	7.56	1.00
Summary for CLEAR LOTIC (13 detail records)							
Min	-0.04	2.77	30.00	60.40	6.64	6.78	0.00
Max	0.31	10.83	2,378.00	107.60	14.56	7.56	66.00

GLACIAL LOTIC

Site/Obs	Depth m	Temp C	Spec Cond. uS/cm	DO %	DO Conc. mg/L	pH	Turbidity NTU
NUKR003 WQ01	0.50	3.32	57.00	101.60	13.54	7.44	60.90
NUKR001 WQ01	0.15	6.42	148.00	53.00	6.53	6.98	3.50
NUKR001 WQ01	0.21	6.35	150.00	50.70	6.25	6.98	6.20
NUKR001 WQ01	0.20	6.29	150.00	50.10	6.19	6.97	3.30
Summary for GLACIAL LOTIC (4 detail records)							
Min	0.15	3.32	57.00	50.10	6.19	6.97	3.30
Max	0.50	6.42	150.00	101.60	13.54	7.44	60.90
Summary for Nuka Bay (17 detail records)							
Min	-0.04	2.77	30.00	50.10	6.19	6.78	0.00
Max	0.50	10.83	2,378.00	107.60	14.56	7.56	66.00

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